Notes on Categorial Grammar and X-Bar Syntax:
Some Fundamental Differences and Similarities

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1. Introduction

The purpose of these notes is comparative/pedagogical but not polemical: to compare fundamental notions of category, syntactic structure, and syntactic function in the two theories for the sake of understanding them, not to argue that one theory is preferable to the other (though that might be an enterprise which could eventually benefit from this comparison). These notes are written mainly for the purpose of getting clear(er) in my own mind, and explaining to my students, what the differences are and are not. Only the most fundamental syntactic notions are treated in this version, but it might well be profitable to pursue this study to examine more complex aspects of the theories as well.

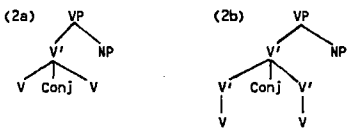
For the sake of concreteness, it might seem appropriate to cite particular instantiations of X-Bar theory and of Categorial Grammar as the basis for my comparison. However, there are multiple variants of both theories that are currently of interest to linguists, and the fundamental level of this discussion would appear not to require differentiation among variants (except a few points as explicitly noted), so I will not single out any particular versions. One could take Gazdar, Klein, Pullum and Sag (1985) as a prototype of the X-bar theories I have in mind and the linguistic papers in Oehrle et al. (1988) as a prototype for categorial grammars, but I do not pretend to discuss either of these literally.

2. Lexical vs. phrasal categories

CG has no such distinction between the lexical and phrasal categories as it appears in X-Bar theory (e.g. V vs. V', the former corresponding to a node in a tree that necessarily dominates only lexical material, the latter one that necessarily does not immediately dominate lexical material). One and the same category of CG may contain both basic expressions ('lexical items') and syntactically complex expressions as members (e.g. *walk, persuade Mary to leave*, both of category VP). However, one can distinguish in CG, as Montague did in PTQ, between *Basic Expressions* of a category A, denoted B_A, and *Phrases* of the same category A, the relationship between the two kinds of categories being defined by the rule

(1) For all Cat A, Basic Expressions of A $\subseteq$ Phrases of A

(for all categories A--it being understood that the syntactic rules then recursively define P_A for all A, using the members of A defined by (1) as the base for the recursion). It is obvious that any expression β analyzed by a CG as of category X will correspond in an X-Bar analysis to (i) a phrasal node XP immediately dominating a lexical node X which in turn immediately dominates β, if $\beta \in B_X$ as well as $\beta \in P_X$, or (ii) a phrasal node XP dominating category nodes of the expressions from which β was produced (i.e. its immediate constituents) if $\beta \in P_X$ but not $\beta \in B_X$. Unless X-Bar theory insists on the distinction between (2a) and (2b) being made--or that (2a) rather than (2b) is necessary for other reasons, the two kinds of description would seem equivalent, ceteris paribus.



This kind of distinction apparently cannot be made in categorial grammar, because basic expressions cannot be operated on by syntactic rules (e.g. coordinated) independently of their membership in phrasal categories. Though one often sees (2a) in X-Bar analyses, from the point of view of categorial grammar it is necessary to write it only because X-Bar theory does permit the category of transitive verbs (or ditransitive verbs, or other subcategories of verbs differing in their complements) to be a phrasal category. And indeed it will apparently always turn out that analyses like (2a) would be unproblematical in CG if they could be viewed as 'abbreviations' for analyses like (2b), since there will always be phrasal categories in CG of the kind that need to be conjoined (or otherwise combined): according to the above described mapping between the two theories, *every* lexical category has a phrasal counterpart in CG (even categories like Determiner and Complementizer), so there would be far more of them than X-Bar theory allows. Lest this seem like a source for a potential economy argument against CG, recall that the lexical (as opposed to phrasal) categories postulated in the above mapping are 'not really there' in CG. Any possible empirical arguments on the inadequacy of CG on this point would apparently have to hang on showing analyses like (2a) as distinct from (2b) really are necessary (and my hunch is this is not likely). Note also that such an argument would probably have to involve syntax alone and not morphology (i.e. not a case where CG could counter with an independently-well-motivated distinction between lexical and syntactic rules, or between morphological and syntactic operations or rules).

3. Bar-levels

CG does not have (and apparently cannot have in general) anything amounting to a distinction between X' and a corresponding X" category (I will henceforth write XP for the (two-bar-level) X" category but continue to use X' for the one-bar-level) nor any distinctions among greater numbers of bar levels. There is traditionally a phrasal-and-lexical category within NP that functions like N' (called CN), but it is important to realize it has this status because of the unusual relationship between (common) noun and NP (= Montague's T-phrase) within CG, which is neither parallel to the relationship between proper noun and NP nor between lexical verbs (of various subcategories) and VP in CG. CN is usually treated as a primitive category; it is predicative (like VP, denoting a set--or in some theories a property), not individual-denoting (like 'first-order' proper names or pronouns), nor having the same kind of reference as NP (if these are generalized quantifiers). The syntactic relationship between CN and NP is of course mediated by assigning determiners to category NP/CN (which makes Determiner neither parallel to modifiers nor to auxiliary verbs categorially, but more like a functor like VP or Comp or TV or Prep). One has therefore a distinction between coordination at the CN level and coordination at the NP level, between NP anaphora (*it*) and CN anaphora (*one*), and between modifiers of CN (adjectives, restrictive relative clauses, and some PPs) and modifiers of NPs (probably non-restrictive relative clauses)--all the things that a distinction between N' and NP buys you in X-bar theory.

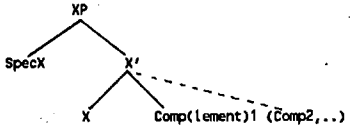
The thing to remember is that nothing analogous to the category CN exists within VPs or PPs or APs, according to most CG analyses. To be sure, there are predicted to be multiple hierarchically embedded 'levels' within such phrases in CG, because of the possibility of adding a modifier to create a higher phrase of the same category, but these are phrases 'at the same bar level'. And within VPs (and some APs and even PPs) there can be multiple arguments of the head V (etc.), which generate internal hierarchical structure (this time, structure often NOT found in the corresponding X-bar analysis), but these are not analogous to V' (or A' or P'--if it exists) as found in X-bar theory either.

As it has sometimes been suggested, N' appears to be better motivated empirically than V' (or A', etc.)--i.e. motivated as genuinely *distinct* from the corresponding 2-bar level category, even to the point of causing doubt in the existence of V' etc.--this might be a place where CG could try to argue for empirical superiority.

On the other hand, an apparent major difficulty for CG lies in the relationship among proper nouns, common nouns, and NPs: accounting for the distributional and morphological similarities among these expressions, in a way compatible with the 'standard' CG category assignments (i.e. those required by their semantics), since these categories are not 'automatically' connected in the way that they are in X-bar theory. How is it that both proper names and common nouns (but not determiners) are heads of their phrases for purposes of morphology, but determiners are (probably?) not, for example? (See below on 'heads'.) Now, semanticists often have a story to tell about the complicated semantic relationship among these three categories, which can be ontogenetic (Partee and Rooth 1983, Dowty 1982, Ladusaw, p.c.)--i.e. an explanation in terms of the need for children to be able to acquire language in steps) or yet more abstract and intricate, in terms of 'fluid' types (Partee 1987), but it remains to be seen how this can be elaborated and motivated in such a way as to cash in on the morphosyntactic generalizations about NPs that X-bar theory claims to capture (or alternatively, to be argued that the strong parallels between NP and other phrasal categories that X-bar predicts are actually somewhat otherwise).

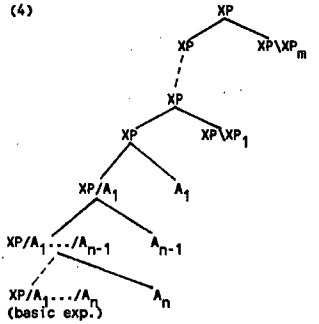
In summary, X-Bar theory postulates that (at least) this kind of structure is common to NP, VP, AP, (and maybe S or other categories).

(3)



While CG offers instead this kind of 'schema', in which $A_1,...A_n$ are arguments of XP, and $XP\backslash XP_1,...XP\backslash XP_m$ are modifiers of XP:

(4)



CG would seem to agree with X-Bar theory on the cross-categorial relationships among X, X' and Complement, and also that modifiers can be added at multiple levels to create a phrase of the same level, and similarly for coordination, but differ in that (i) if *Determiner* is a Specifier, then its relationship to NP and N' (= CN) can be reconciled in CG with what X-bar theory says about it, but that this 'specifier' relationship probably does not exist elsewhere; (ii) in CG auxiliary verbs are not specifiers of VP but are the heads of VPs taking other VPs as complements (and GPSG agrees with this position of course, though it adopts X-bar theory in other ways)--a kind of possible exception being found in the 'type-raised modal' analysis of Bach (1979) and Dowty (1979) (modals as (S\NP)/VP, all other verb phrases

being VP of a lower type) which gives modals and possibly all tensed auxiliaries a status something like 'Specifier'; (iii) CG, unless its 'binary' nature is diluted by the addition of flattening principles, will have as many additional constituent groupings within an XP as the head of XP has arguments numbering more than two (i.e. *give Mary a book* has an additional sub-constituent not found in *see Mary*).

4. Grammatical categories vs. grammatical functions

4.1. Heads

(It's not completely clear to me what status 'head' has in this typology, but I'm including it here anyway.)

The obvious way to think of heads in terms of CG is that functors are uniformly heads of the constituents they form with their arguments if this worked, it would be a great advantage of CG, since you could in effect predict from semantic considerations (sometimes) what the head was going to be (or vice-versa from morphosyntactic ones)--a very highly predictive feature of a theory, potentially.

The equally obvious problem is modifiers: they are functors, but traditional usage of the term 'head' (cf. Zwicky 1985, Gazdar et al. 1985) demands we treat their arguments as heads, not modifiers. (Bob Carpenter in his dissertation (Carpenter 1988) develops a theory where all such generalizations are stated in terms of 'functor', without distinguishing modifiers from 'real' heads; Bach (1983) also treats the agreement and government properties of modifiers without formally distinguishing between them and other functors--cf. below.)

One could try defining head by saying (making the type-token distinction only implicitly, in a way familiar to linguists):

(5) In [A/B B] of category A, A/B is the head except where A = B; then, B is the head.

The problem with this is there are cases where A does happen to equal B, yet it's obvious A/B is the head and B its complement--for example auxiliary verbs take VP to form a VP; but the auxiliary verb is traditionally considered the head. Equi verbs are similar. Now maybe the *sub*category is different in most cases, but there may be a few base-base cases like *go soak your head*, *run get the beer*, and there are certainly transitive counterparts like *help John wash the dishes*, *see Mary win the race*, so I wouldn't want to pin my definition on the same-subcategory/different-subcategory distinction. This implies 'head' must be a syntactic primitive in some sense or other, if modifiers need to be explicitly singled out.

4.2. Inherent functor features

One interesting question for formalizing a definition of category in CG that allows a 'modern' system of features is whether a functor category A/B can have features qua functor category, or only features defined for A (as part of its definition of its result category) and features defined for B (ditto argument category)--though of course each of these can be recursively complex in the same way: this theory implies all your features are ultimately defined on one of the primitive categories, so there are no features peculiar to complex categories. (Carpenter, at least, uses such a restricted theory of features.) The other theory would merely regard 'Argument Category' and 'Result Category' as two category-valued features that go into defining a category (like SLASH in GPSG), possibly among other features as well. (Bach 1983 explicitly allows for 'inherent' features for complex categories, though he doesn't actually use them, though Zeevat, Klein and Calder 1987, Uszkoreit 1986, and Karttunen 1986 do make use of inherent features.)

Now although it might be technically possible to treat 'head' as a feature definable on a primitive category (still without distinguishing A/A from A/B), I believe the definition would be awkward and would have unintuitive consequences. But rather than open the door to just any arbitrary inherent functor features, maybe one should consider (for the time being) 'head', alongside 'direction of slash', which is likewise necessarily an inherent functor feature if it exists at all, to be the *only* inherent features.

A simple way to formalize such a theory would be as follows:

(6) 1. The Primitive categories are .... (finite list).

2. If A and B are any categories, A/B and A\B are categories.

3. If A is a category, A//A and A\\A are categories.

The idea is that A//A is the category of modifiers--each syntactically distinct but of the same semantic type as the corresponding A/A (where the second A is a complement). 'Head' is then defined by saying:

(7) (i) in [A/B B], A/B is the head, and
(ii) in [A_i//A_j A_j], A_j is the head.

(This is of course a disjunctive definition--as Venneman and Barlow's definition also is, as pointed out by Hawkins 1984 (see Hoeksema p. 59)--but that would not be too bad if it turned out that one needed to ascribe properties to one of the two subtypes separately from the other.) Note also the Greenberg universal word order tendency is easily described as a tendency to put heads and non-heads in the same order (i.e. in VO languages, functors tend to precede arguments, but modifiers tend to follow arguments; vice-versa for OV's.) In describing agreement and government in morphology, one would then want to treat A/B and A//B differently; cf. discussion of Bach (1983) below.

A more difficult question is whether the notion 'head' is really needed in a categorial theory of syntax. Pace Zwicky (1985), Bach (1983) argues that the notion 'head' is unnecessary for describing generalizations about inflectional morphology involving agreement, government, and selection in a categorial grammar with a well-developed system of morphosyntactic and morphological features, and he provides a significant fragment of modern German inflectional morphology and syntax formalized in this theory. Briefly, Bach's system works as follows. Morphosyntactic features are defined (essentially, though not in these terms) as attribute-value pairs (i.e. pairs consisting of a feature and its (unique) feature-value), and primitive categories are sets of these. A functor category A/B is then defined as an ordered pair consisting of a set of argument feature-value pairs (defining B) followed by a set of result feature-value pairs (defining A). Bach's general form of a syntactic rule incorporates principles of Government, Agreement and Inheritance ('Percolation') (cf. p. 79) and is stated as in (8), which is taking as recursively defining F(x), the morphological form of every derived expression x:

(8) If $\alpha \in A/B$, $\beta \in B$, and o is the associated syntactic operation,
then $\delta \in A$, where δ =
o(G(α), H(β)) and
F(δ) = I(F(α), F(β))

where:

G = agreement and must be a function on F(β)
H = government and must be a function on F(α)
I = percolation and must be a function on (F(α), F(β))

In other words, the functor expression α (in A/B) will, in the combined expression, acquire 'agreement' morphological features that depend on features of its argument β (cf. Keenan's principle 'functors agree with their arguments'), and the argument expression β (in B) will acquire features governed by its functor α. In addition, the derived expression can 'inherit' features from both inputs: Bach's principle for this (cf. p. 81) says, roughly, that if the result category shares some feature(s) with the argument category, then the feature values of these shared features are inherited from the argument to the result; the feature values defining the category of the resulting expression are otherwise those specified in the result-category symbol of the functor (i.e. A in A/B).

In this system, endocentric modifiers are simply stipulated to have the feature set $\langle\emptyset, \emptyset\rangle$, i.e. no government features and no (lexically inherent) agreement features: then in the context of this system, they are 'completely transparent with respect to the features of their arguments'.

In fact, we can almost take the feature set $\langle\emptyset, \emptyset\rangle$ as defining an endocentric modifier (and therefore indirectly determining 'head'): we cannot quite, because there is nothing in Bach's theory which insures that only expressions of A/A receive this feature set, rather than, say some expression of A/B for $A \neq B$ (which would be rather heads of non-endocentric constructions that just happen not to govern any features or have any inherent features with which other functors must agree). So (endocentric) modifiers must be expressions of A/A or A\A which have features $\langle\emptyset, \emptyset\rangle$, and heads can in turn be defined in terms of these. The question to ask is, does Bach miss any generalizations by not being able to refer to heads directly? Within the context of his theory, it is not obvious that he does. That should be a starting point for a close examination of this issue, which is beyond the scope of the present discussion. Carpenter's treatment should provide a second example, formalized in a somewhat different way. Note that Zwicky (1985) (like Hoeksema 1985) is concerned with 'head' in derivational morphology as well as inflectional morphology and syntax, whereas Bach (and probably Carpenter) is/are not.

4.3. Grammatical functions

Much traditional grammatical wisdom has it that grammatical categories (noun, NP, Adverb, PP, etc.) and grammatical functions (subject, direct object, modifier, time adverbial, free adjunct, etc.) are distinct notions and should not be confused; some linguists (Arnold Zwicky, p.c.) would still seem to want to give such a principle the status of an a priori methodological assumption that is fixed before questions of the form of a linguistic theory can begin to be discussed. (Grammatical functions are of course taken to be definable in terms of other notions, such as constituent structure and linear order, in some theories but as primitives in others, such as relational grammar and LFG, but this statement applies equally to both kinds of theories.) However, categorial grammar would seem to ignore this boundary between category and function, since it provides characterizations of at least some grammatical functions (and some would argue, of all grammatical functions necessary in linguistic theory: Dowty 1982) in its category assignments and constituent structures.

For expressions used as arguments, the grammatical function of the expression is determined not by the category of the argument itself but by the functor that is combined with it in a particular sentence: below are some examples. Note two important caveats here: we say 'expression used as argument' and not 'argument category', since expressions of the same category, say the 'NP' category S/VP, can be used sometimes as arguments and sometimes as functors by the same grammar; similarly, position in the grammatical structure of a sentence is relevant, since argument expressions of the same category can have multiple grammatical functions within a single sentence. English word order is used for the sake of familiarity below, but it is to be understood that the definitions are essentially in terms of functor-argument relations, not linear order.

For expressions used as functors in a particular situation, on the other hand, grammatical function (or at least part of it) is defined by category. There are two main kinds of these: *modifier of A*, where the functor is A//A or A\\A, and cases where the functor is a non-modifier. In that case, there may be some traditional name for the functor's grammatical function (such as 'predicate') but in most cases there will not, a traditional term existing only for the corresponding subcategorization frame, if even that (as in the case of the grammatical function of (VP/VP)/NP in [(VP/VP)NP NP]). Because grammatical category and grammatical function must coincide for functors, a functor expression which has more than one 'grammatical function' must be assigned to more than one syntactic category, e.g. VP-modifying adverbs and S-modifying adverbs must be assigned to different categories (cf. just below); this characteristic has been viewed by some as an undesirable property of CGs.

(9) Examples of grammatical functions defined by categorial grammar (categories used as variables over expressions):

a. In [NP NP\S], NP has the grammatical function subject and NP\S has the function predicate.

b. In [VP/NP NP], NP has the grammatical function direct object and VP/NP has the function transitive verb (phrase).

c. In [(XP\\XP)/NP NP], NP has the function object of preposition.

d. In [VP/VP VP], VP has the function VP complement.

e. In [VP/S' S'], S' has the function sentential complement.

f. In [S S\\S], S\\S has the function sentential modifier.

g. In [VP VP\\VP], VP\\VP has the function VP modifier.

h. In [CN CN\\CN], CN\\CN has the function noun modifier.

(The list is not exhaustive). Some familiar grammatical categories do not appear as such in CG: for example, Adverb, Adverb Phrase, Preposition, and Prepositional Phrase do not exist in exactly parallel form in CG: rather, there are only the phrasal categories S-modifier (S\\S), VP-modifier (VP\\VP), and so on, each of which may contain both solitary lexical expressions ('S-adverbs', 'VP-adverbs'), as well as complex phrases consisting of an adverb and modifier ('Adverb Phrase'), a preposition and object (e.g. [(S\\S)/NP NP], a 'Prepositional Phrase'), a preposition and two complements ([(VP\\VP)/NP)/Adj NP Adj], e.g. *with the president absent*) or a sentence and adverbial subordinating conjunction (e.g. [(S\\S)/S S], an 'adverbial subordinate clause'). However, we can usually give cross-categorial characterizations in CG that correspond to the traditional classes, e.g. the category 'Preposition' can be said to correspond to (X\\X)/NP in CG, i.e. prepositions are words that combine with a following NP to form a modifier of any category. It could conceivably be regarded as a deficiency of CG that it 'predicts' that (some or all) prepositions could idiosyncratically form modifiers of certain categories but not others (say of CN and S but not VP), whereas it may be a (nearly or absolutely) universal fact about languages that in any language which has the category at all (cf. Schachter 1985), PPs modify S, VP, CN and probably various subcategories of these indiscriminately. Of course, many lexical items generalize with greater or lesser productivity across various grammatical (sub-)categories, and the means for describing this will have to be adopted in any event (and various such systems have already been proposed), so it's not clear any important generalization need be lost if one appeals to schema such as (X\\X)/NP as lexical categories. On the other hand, other kinds of modifier (adverb and adverbial subordinate clauses) are now known to need to be divided into 'VP-Adverbs' vs. 'S-Adverbs' for various descriptive reasons (Stalnaker and Thomason 1973, McConnell-Ginet 1982, Ernst, ms.), so it's clear these kinds of modifiers have to be kept distinct in general.

So far, however, there is no real problem for the clear-cut distinction between grammatical category and grammatical function: even if certain categorial relationships

'correspond' to definitions of grammatical functions, the purist can maintain that the actual 'grammatical functions' themselves can still be regarded as of a different kind, on a different plane, as it were. If a problem arises, it would probably be with phrases such as *every Thursday* in the context (10):

(10) Mary met John every Thursday in the garden
Thursday morning
this Thursday
the first Thursday
after Easter

One can imagine a purist insisting that the phrases *every Thursday* etc. belong to the category NP (and to no other category) because (i) they have the internal syntax of a NP, and (ii) they share ordinary NP distribution (e.g. *This Thursday is my birthday*); the 'adverb-like quality' of this phrase, it would be argued, is a matter of grammatical function, not grammatical category, and it would be a confusion of category with function to call these Adverb Phrases (or NPs exhaustively dominated by AdvP).

However, not just any NP can appear here (**Mary met John a false proposition in the garden*), but only one referring to an interval of time; note also that a few temporal phrases require a preposition *on* or *in* in such contexts (*Mary met John *(in) January in the garden*) and *on* (or *during*) *can* occur optionally with all of the 'bare NP' phrases. Since these are clearly adjuncts, by their distribution and by their semantics, CG requires us to assign them to a modifier category such as S\\S or VP\\VP (though of course they may be derived from NPs by an 'adverbialization' rule or by combining with a 'phonologically null' preposition): the option of calling them 'NPs' apparently does not exist in this theory. If this is indeed a case where phrase structure grammars either demand assignment to category NP or offer an analytic choice between NP and an adverbial category, then some might want to argue that CG here forces the correct choice. (See McCawley 1988 for detailed discussion of two further views on this data; note that, like CG, McCawley takes the 'external syntax' of adverbially-used NPs as relevant to determining their category, not just their internal syntax.)

5. Category raising and head-agreement-government generalizations

Systems of categorial grammar are of course now widespread in which so-called 'Category Raising' takes place (several examples are in Oehrle et al. 1988); either as a lexical process (i.e. expressions are entered in the higher type in the lexicon, but no general rule exists for changing an arbitrary category) or as an unrestricted 'syntactic' (and possibly recursively self-feeding) process. Category Raising reverses the functor-argument relationship between two expressions and so would wreak havoc with any generalizations about agreement and government in terms of category, unless countermeasures of some kind are taken.

5.1. Type polymorphism

There are basically two ways to have the category-raising cake and eat it too: first, one can relegate all type-raising to the semantics and so leave the true syntactic categories unaffected: this is sometimes called the 'type polymorphism' approach (see e.g. Partee 1987). For example if the fundamental form of the grammar has the categories e (name) and S\e (VP), and if by type-raising the category e is reinterpreted as denoting functions from S\e denotations to S denotations (NPs, in their semantic role as quantifiers), then for syntactic purposes S\e nevertheless continues to count as 'functor' and e as 'argument'. This might appear to be a strange strategy to a logician working with categorial grammar, since for her the whole point of using the categorial notation to name categories is that the logical type of the category is automatically made apparent. But for linguists interested in the natural language generalizations of word order and morphology that on the one hand seem sensitive to the functor-argument distinction in a basic way but are apparently unaffected by type raising (if semanticists are right in identifying the points at which it occurs), this is a natural

kind of theory to pursue (even if we turn out to need a 'double' notation for categories and types of expressions to avoid confusion).

5.2. 'Structure-preserving' category raising

Another possibility would be to incorporate category raising as an operation which does indeed change syntactic category but try to add to this a mechanism for making systematic concurrent changes in the organization of agreement and government morphology for that category, etc. so as to preserve the apparent morphological and syntactic relationships among expressions that existed before category raising--much as Dowty's (1989) analysis of non-constituent conjunction carefully preserves word order in spite of category raising. This looks less practical on the face of it, but who knows whether it could be made workable in some reasonably elegant and ingenious way?

6. Other topics

As mentioned at the beginning of these notes, only the most fundamental properties of the two approaches are treated here. A full comparison of them would necessarily involve a number of other issues which are more complex, because language itself is more complex in these phenomena, because there is not a single approach in categorial grammar (or in X-bar theories) but several mutually incompatible methods, or because semantic as well as syntactic issues are involved. These include but probably should not be limited to:

i. the use of context-free operations only vs. use of more complex operations such as 'wrapping' (cf. Bach 1984).
ii. (closely related) the use of non-context free operations vs. the use of metarules and 'flattening' rules to capture discontinuous (bounded) dependencies.
iii. The use of functional composition in CG to capture non-normal constituents, as in clause union or non-constituent coordination, vs. ways of describing these in X-bar theories.
iv. The use of feature-passing vs. movement transformations vs. functional composition to describe unbounded dependencies.
v. The use of unification in some versions of CG and HPSG vs. other methods of feature matching.

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